



Powering Innovation That Drives Human Advancement

Ansys Forming – Accurate, Scalable, Process-Driven GUI for Metal Forming Simulation

Xinhai Zhu

Agenda

- Introduction of Ansys Forming
 - History review
 - Ansys Forming GUI
- Typical applications
 - Multi-step forming
 - Clamping
 - TWB simulation
 - Springback compensation
 - Trimming curve development
 - One step method
- Key functions
 - Solid element in stamping simulation
 - Mesh check/repair
 - Mesh regeneration
 - Formability Index
 - 3D drawbead generation of bead force prediction
 - Non-linear contact
 - Variable friction
 - New universal material model
 - Reconfigurable settings
- Exciting future



Introduction

Background

- LSDYNA has long been used in stamping simulation
 - LSDYNA was one of the first commercial FEA software for stamping simulations
 - Has built a strong reputation for its accuracy, especially in springback prediction
 - Used to rely on third-party GUI for stamping simulation.
- Ansys Forming is a dedicated package to stamping simulation
 - Integrated GUI - Pre, solver and post processing
 - A Designer's tool
 - Can simulate the entire stamping process within a single platform
 - Streamlined Formability/Trimline development/Springback Compensation functions.

Design Objectives

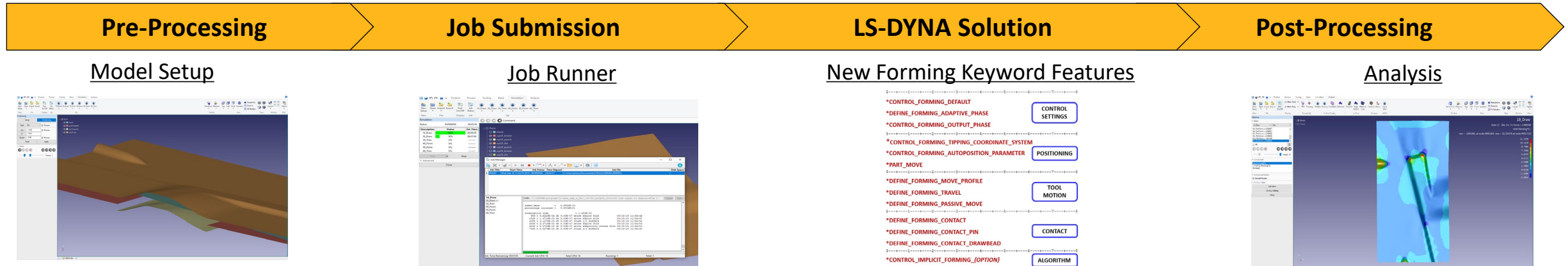
Easy to use - Friendly user interface for intuitive use.

Efficient - Smart adaptivity, contact auto move, new material algorithm, scalability through MPP, in- core technology.

Robust - automatic normal check for contact, optimized setting, consistent solution.

Fully Integrated Platform

- Ansys Forming provides a unique platform which has a seamless fully integrated GUI with pre-post processing and uses LS-DYNA as a solver.
 - Easy to setup multi-stage forming simulations
 - Customizable template-based method allows user to easily define different forming processes
 - A job-submitter allows user to run the job easily
 - User can seamlessly evaluate simulation results when the job is running

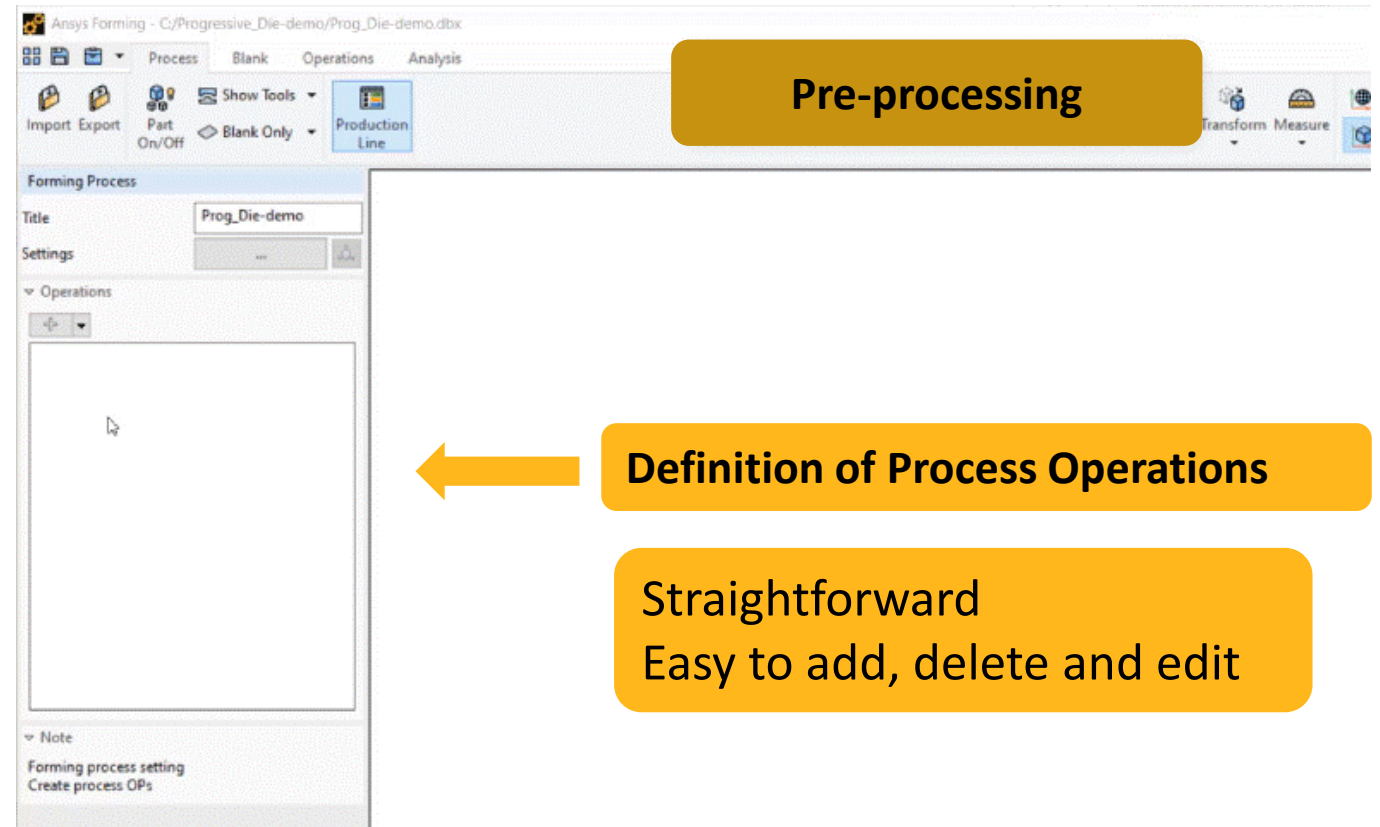
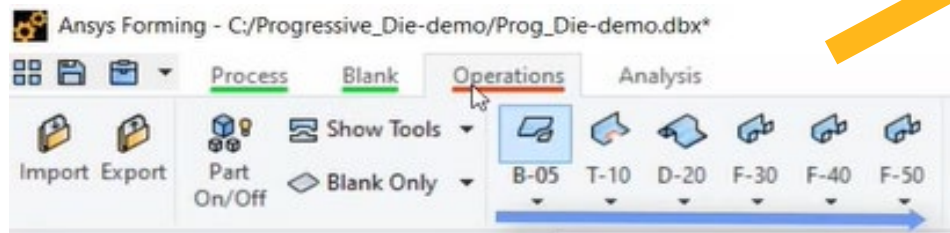


Process-based Workflow

During process design/verification, engineers must perform the simulations of drawing and secondary operations, such as trimming, flanging and restriking, as well as springback.

Process-based workflow is the key to analyze and optimize all the operations of a stamping process.

Straightforward Operation Definition
Easy to use: ADD, DELETE & EDIT



Definition of Process Operations

Straightforward
Easy to add, delete and edit

Preset/User-Defined Process Templates

Preset Process Templates

Draw operation

CrashForm(2pcs)

☐ Gravity

+Tool	Drawing
Die	Cls to Punch
Punch	Fixed on Bed

Flanging/Restrike

Double_Action(3pcs_ToggleDraw)

☐ Gravity

+Tool	Closing	Drawing
Punch	Stationary	Travel-> Pos: 0
Binder	Cls to Die	Stationary
Die	Fixed on Bed	Fixed on Bed

FormTrim

FormTrim(4pcs)

☐ Gravity

+Tool	Closing	Forming
Pad	Cls to Post	Stationary
Flg1	Stationary	Travel-> Pos: 0
**CutTool1	Drv by Flg1	Drv by Flg1
Post	Fixed on Bed	Fixed on Bed

Single_Action(3pcs_AirDraw)

☐ Gravity

+Tool	Closing	Drawing
Die	Cls to Binder	Travel-> Pos: 0
Binder	Stationary	Drv by Die
Punch	Fixed on Bed	Fixed on Bed

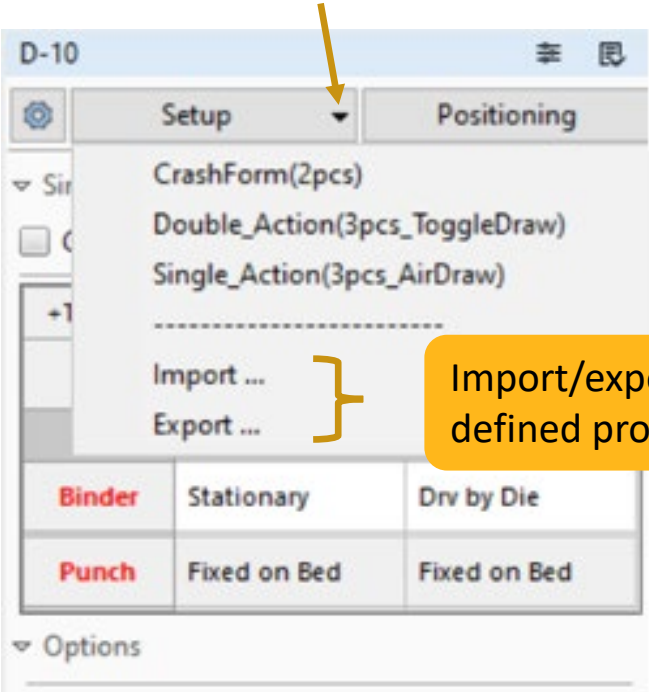
Flanging(3pcs)

☐ Gravity

+Tool	Closing	Forming
Pad	Cls to Post	Stationary
Flg1	Stationary	Travel-> Pos: 0
Post	Fixed on Bed	Fixed on Bed

Convenient to set up a typical process
Guidance for new forming users
Easy to edit for a complicated process

Drop down for a preset or user-defined process template



Import/export a user-defined process template

Innovative Tabular Tooling Setup

Flexible, easy and straightforward

Preview/adjustment of tool positioning

- Flexible to define complicated tool motion
- No limitation on total tool number
- Easy to manage the tools and accessories
- Integrated with gravity and springback options

Click '+ Tool' to add a new tool

The first column is the tool list

The screenshot shows the 'D-10' tooling setup window. It has tabs for 'Setup' and 'Positioning'. Under 'Positioning', there's a section for 'Single_Action(3pcs_AirDraw)' with a 'Gravity' checkbox. Below this is a table with three columns: '+Tool', 'Closing', and 'Drawing'. The first row is for 'Die' with 'Cls to Binder' and 'Travel->Pos: 0'. The second row is for 'Binder' with 'Stationary' and 'Drv by Die'. The third row is for 'Punch' with 'Fixed on Bed' and 'Fixed on Bed'. Below the table are 'Options' (Springback checkbox) and 'Accessories' (Guide Pins, Drawbeads buttons).

+Tool	Closing	Drawing
Die	Cls to Binder	Travel->Pos: 0
Binder	Stationary	Drv by Die
Punch	Fixed on Bed	Fixed on Bed

A close-up of the '+Tool' dropdown menu. It shows two options: '+Cutting Tool' and '+Phase'.

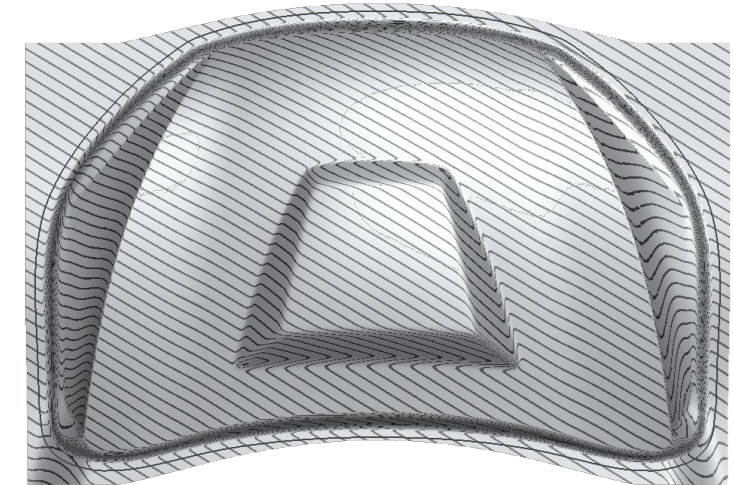
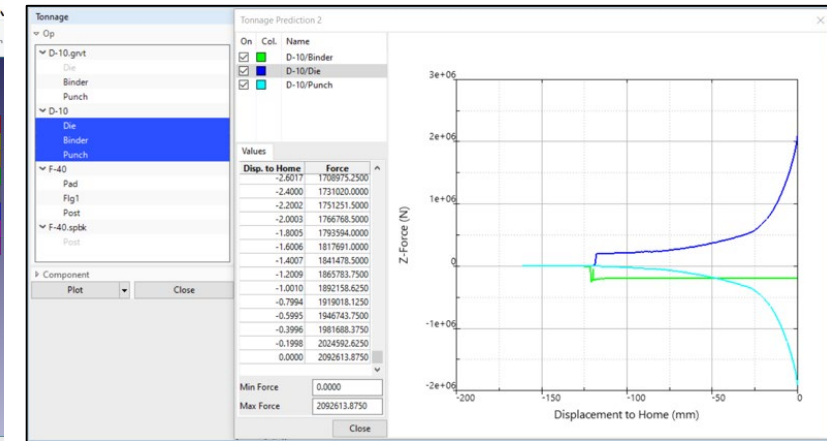
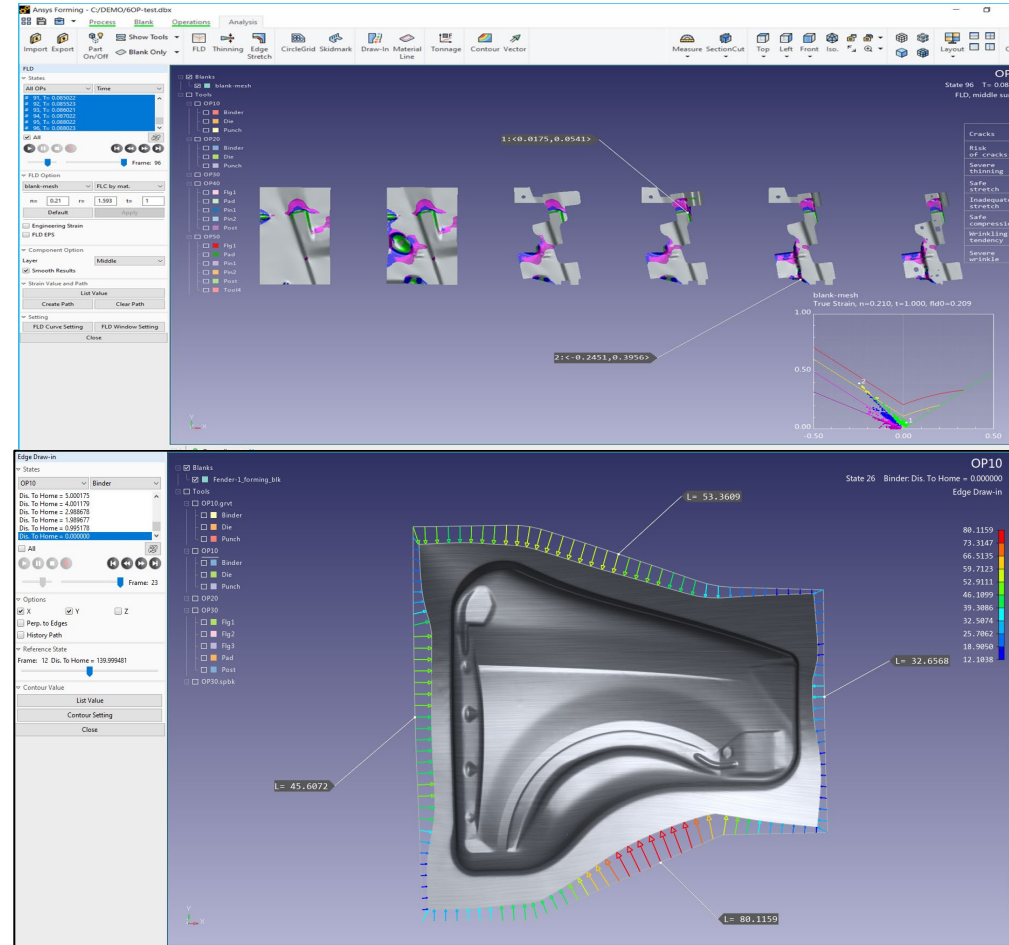
Drop down from '+ Tool' and click '+ Phase' to add a new motion phase

The first row is the motion phase list specifying the tool motion phases in current operation stage

(e.g., a binder-closing phase and a drawing phase for a 3-piece air draw process)

Provide all the necessary post processing functions

- ❑ Intuitive GUI
- ❑ Special forming modules
- ❑ Integrated post-processing of multi-stage jobs
- ❑ Easy multiple-window management
- ❑ Up-to-date graphic rendering
- ❑ High software stability





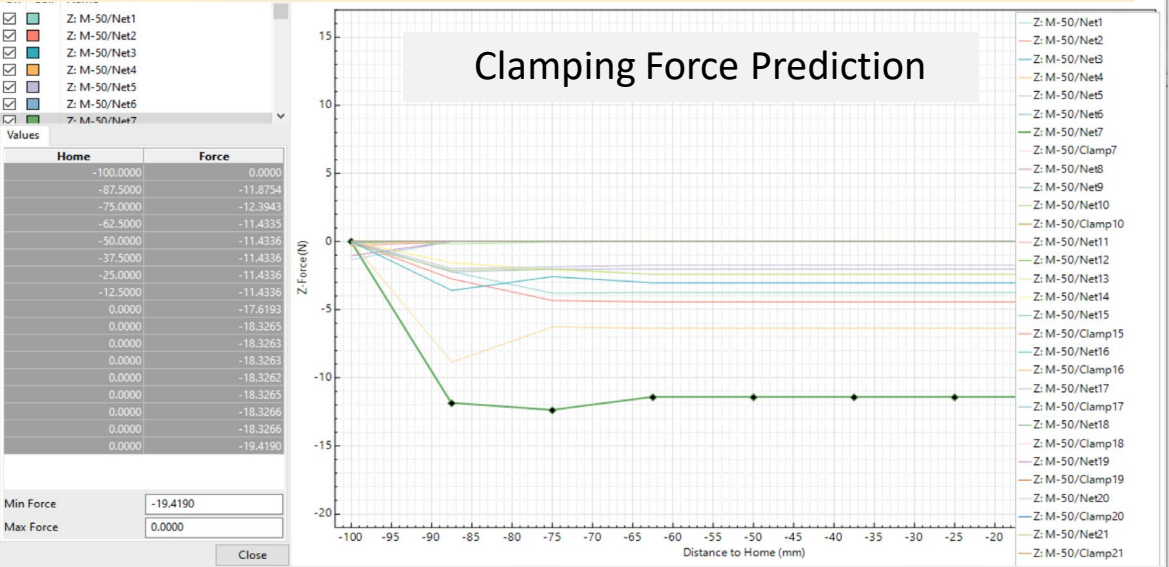
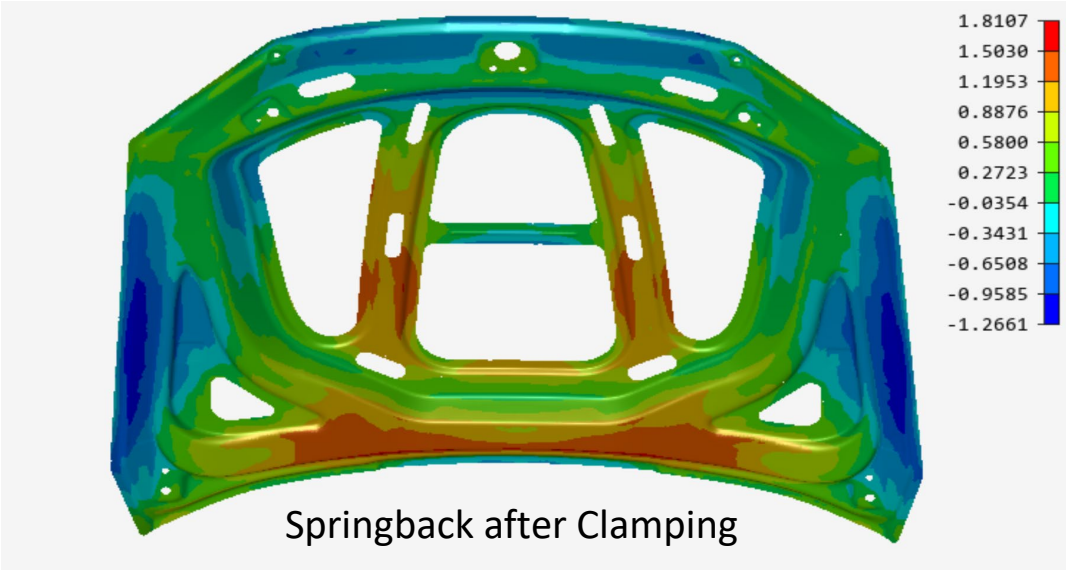
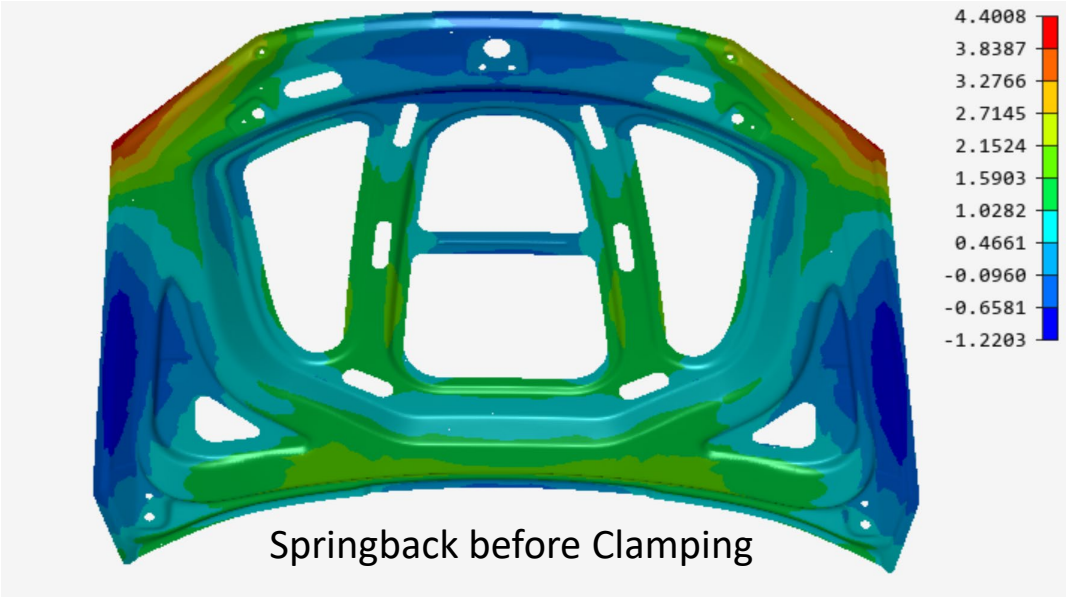
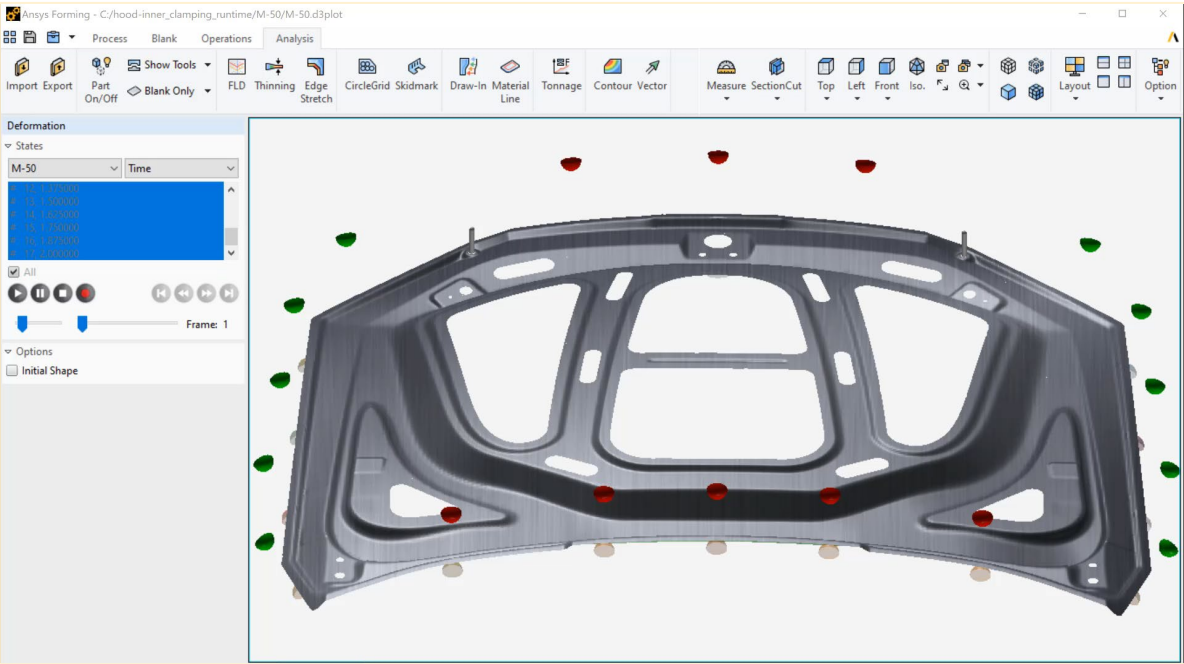
Typical Applications

Traditional stamping simulation

- Simulation of entire stamping process
 - blanking
 - Gravity loading
 - Draw
 - Trimming
 - Flanging/restriking
 - Spring back

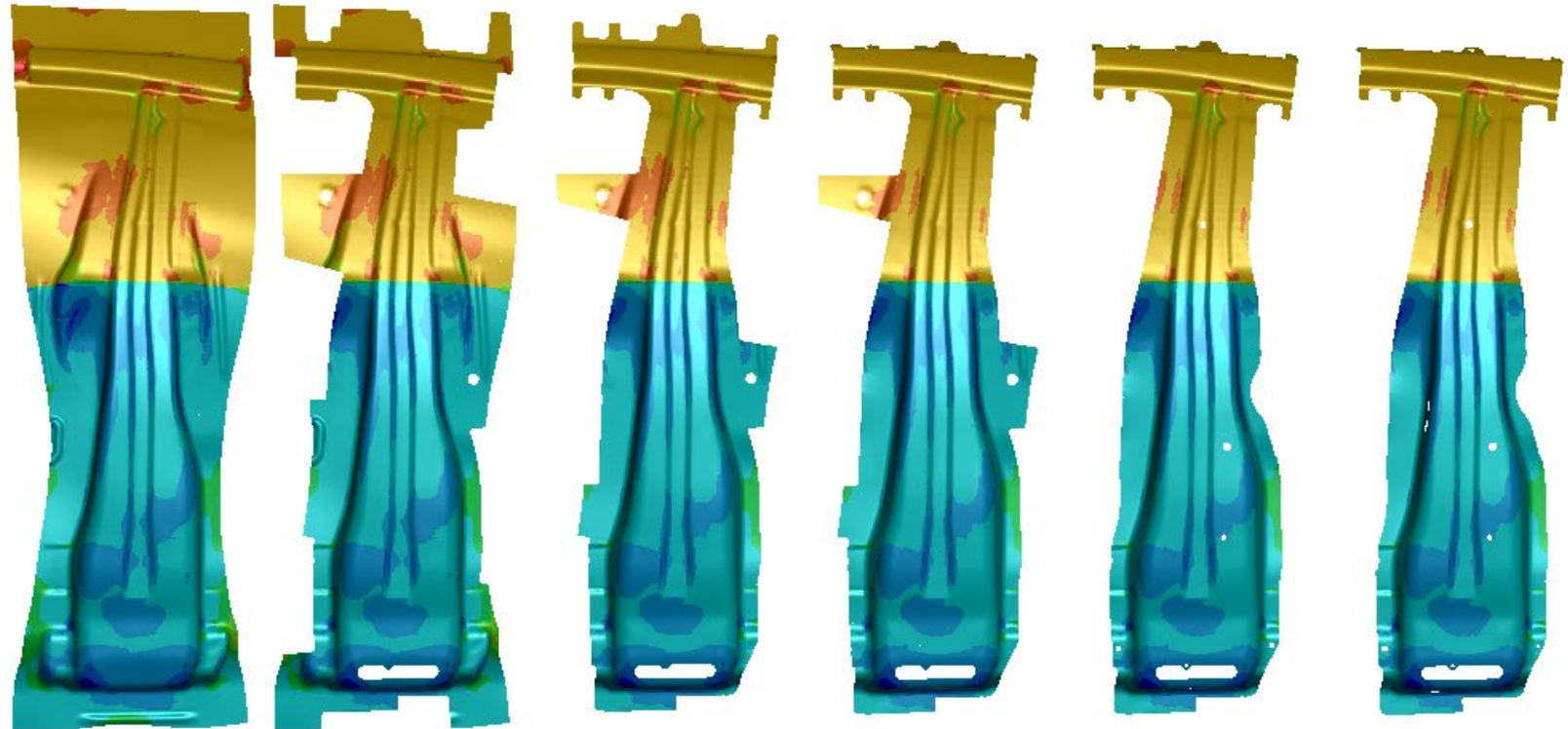
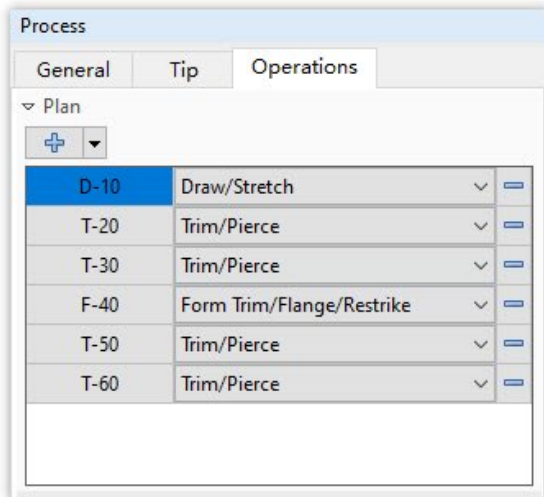


Clamping Simulation



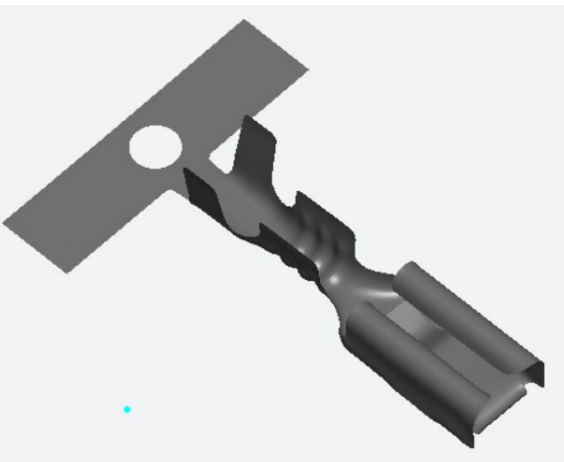

Tailor Welded blank

- 2025R2 enables the creation of tailored blanks with multiple weld lines



Progressive Die process

- The process involves 20 stations



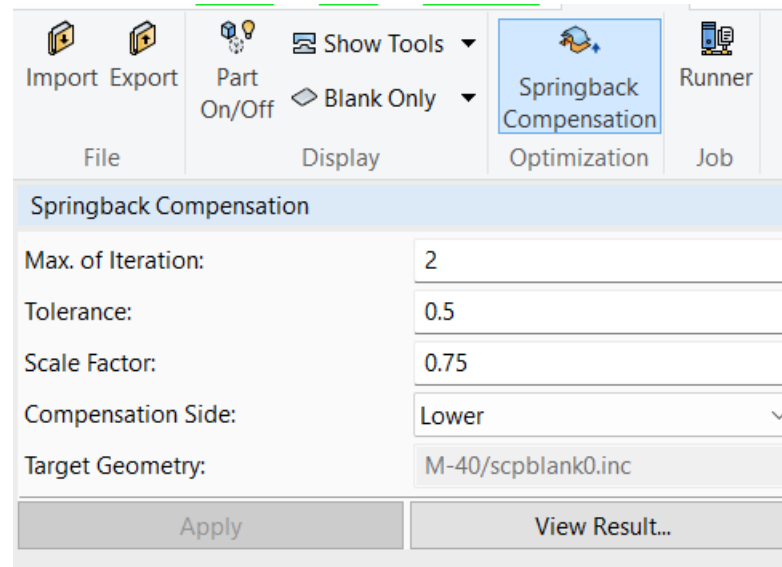
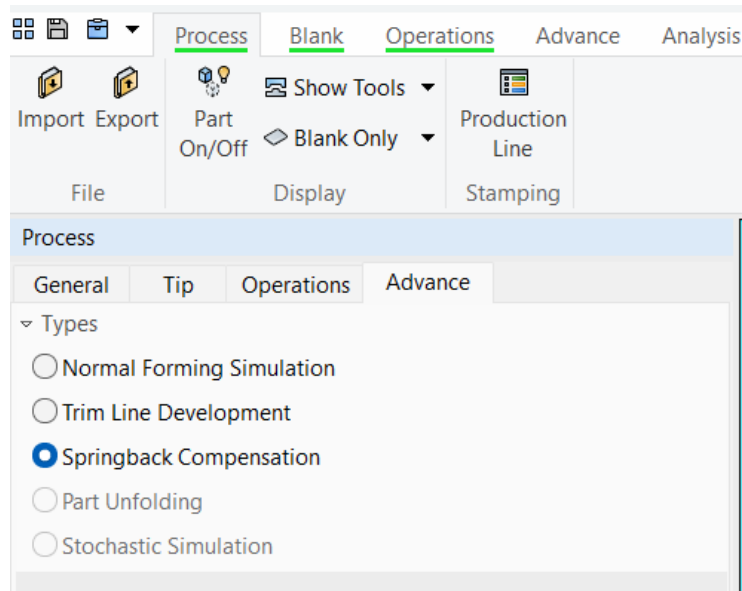
The image displays the Ansys Runner interface for a progressive die process. The interface includes a top toolbar with tabs for Process, Blank, Operations, and Analysis. The Operations tab is active, showing a sequence of 20 stations: B-05, T-10, T-20, D-30, D-40, T-50, T-60, D-70, D-80, D-90, D-100, D-110, D-120, D-130, D-140, D-150, D-160, D-170, and D-180. The Runner window shows the status of each station, with a table of Description, Status, and Time. The overall status is COMPLETED, and the total time is 01:30:19.

Description	Status	Time
B-05	blanking	100% 00:00:08
T-10	trim	100% 00:00:04
T-20	trim	100% 00:00:06
D-30	draw	100% 00:02:32
D-40	draw	100% 00:07:12
T-50	trim	100% 00:00:06
T-60	trim	100% 00:00:04
D-70	draw	100% 00:00:26
D-80	draw	100% 00:01:37
D-90	draw	100% 00:00:43
D-100	draw	100% 00:22:29
D-110	draw	100% 00:02:27
D-120	draw	100% 00:07:42
D-130	draw	100% 00:23:10
D-140	draw	100% 00:05:32
D-150	draw	100% 00:03:54
D-160	draw	100% 00:07:58
D-170	draw	100% 00:02:47
D-180	draw	100% 00:02:27

Settings: CPU = [] Memory = [] (MB) Default

Springback Compensation

- The springback compensation provides a workflow to correct the springback deviation
 - Iterative method
 - Fully automatic
- Springback and draw forming can have different coordinate system



Maximum number of iterations

Maximum difference between target and final part geometry

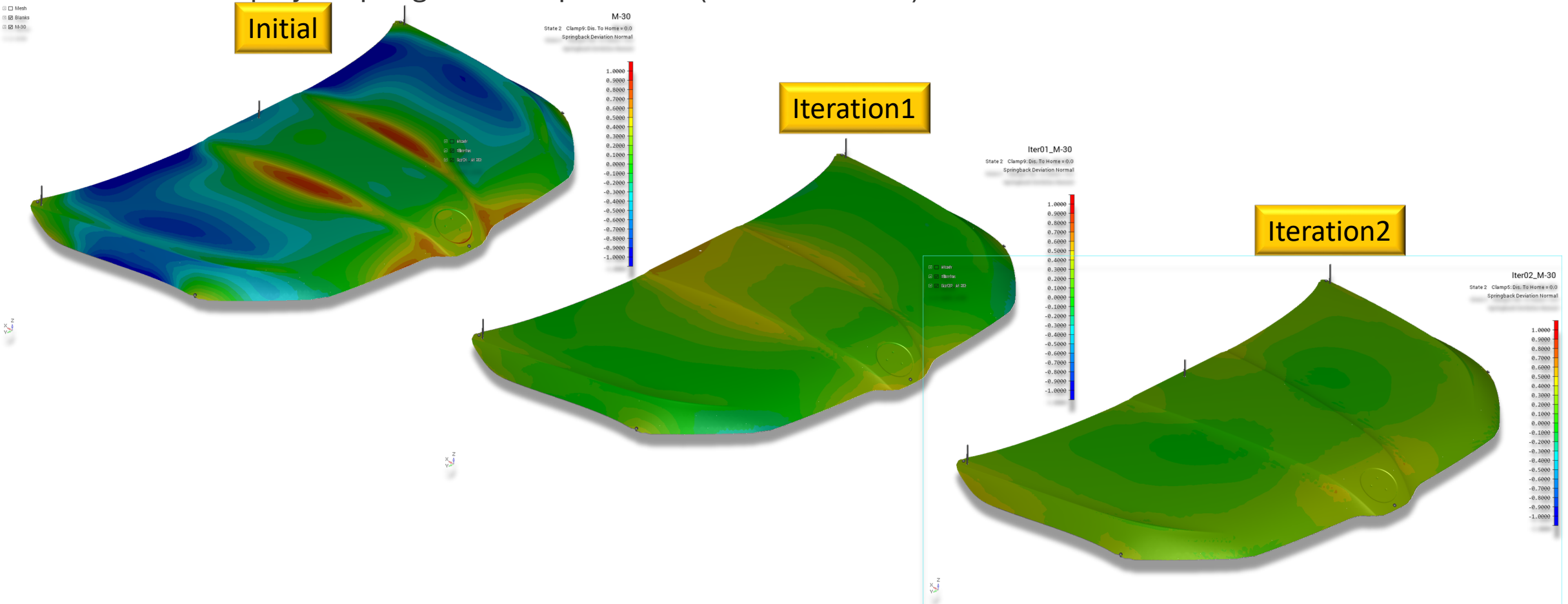
Scaling of the compensation (0-1). Scaling equals 1 will compensate faster

Point to the side of the tools to be compensated

Springback Compensation

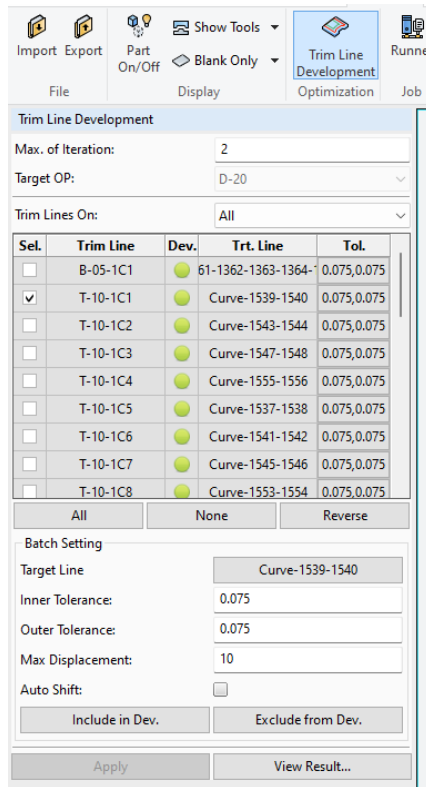
- **Postprocessing**

- Result display of springback compensation (Blank deviation)



Trimming Curve Development

- The user interface facilitates setting up the development of trimming curves
- For every iteration, the user can evaluate the resulting part geometry to the target boundary



→ Run trimming curve development

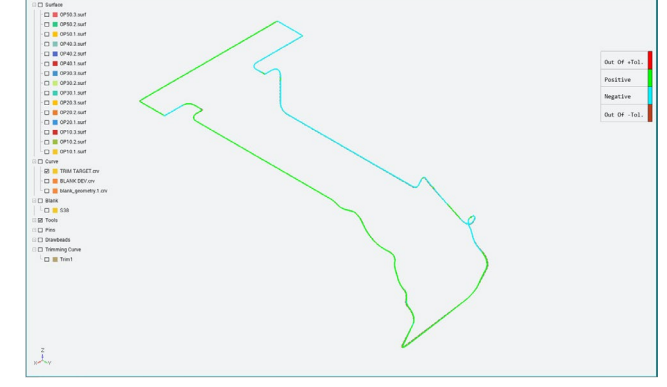
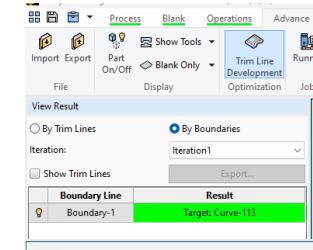
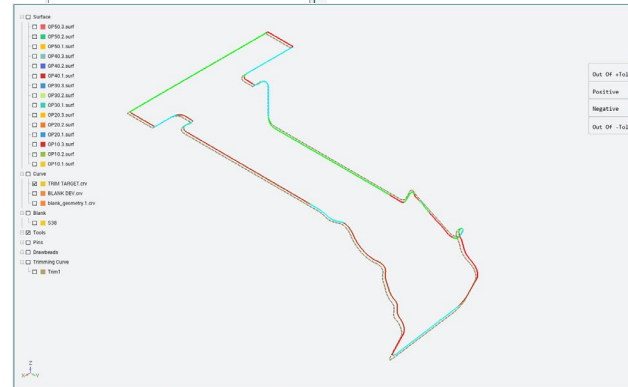
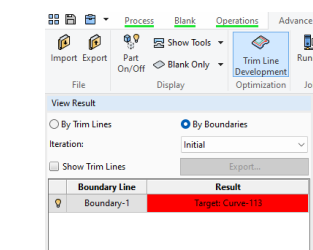
→ Edit the development of each trimming curve

→ Define target geometry

→ Define tolerance

→ Enable autoshift

→ Evaluate results



Dedicated evaluation for the development of the trimming curves

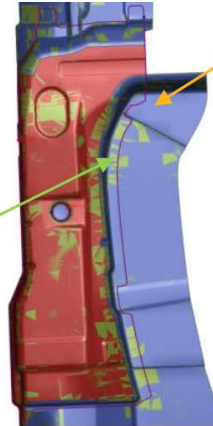
Trimming Curve Development - 2

- Example



Target Line

Trim Line



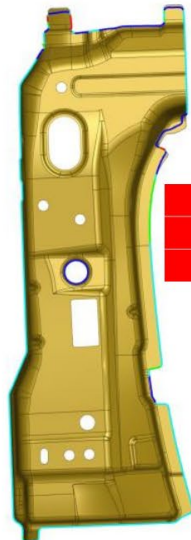
Trim Line Development				
Max. of Iteration:	10			
Target OP:	T-50			
Trim Lines On:	All			
Sel.	Trim Line	Dev.	Trt. Line	Tol.
<input type="checkbox"/>	T-20-1C4	●	Curve-42	0.5,0.5
<input type="checkbox"/>	T-20-1C5	●	Curve-41	0.5,0.5
<input type="checkbox"/>	T-20-1C6	●	None	0.5,0.5
<input type="checkbox"/>	T-20-1C8	●	Curve-42	0.5,0.5
<input type="checkbox"/>	T-20-3C1	●	Curve-42	0.5,0.5
<input type="checkbox"/>	T-30-2C2	●	None	0.5,0.5
<input type="checkbox"/>	T-30-2C3	●	None	0.5,0.5
<div> <div>All</div> <div>None</div> <div>Reverse</div> </div>				
Batch Setting				
Target Line				
Inner Tolerance:				
Outer Tolerance:				
<div> <div>Include in Dev.</div> <div>Exclude from Dev.</div> </div>				
<div> <div>Apply</div> <div>View Result...</div> </div>				



```

$-----
*INTERFACE_TRIMMING_CURVE_DEVELOPMENT
$ IOPTION GAPMIN
$      2      1.0
$ vx      vy      vz      depth      tol1      tolo      DMAX
$      0.0      0.0      -1.0      0.0      0.50      0.50      10
    
```

Initial

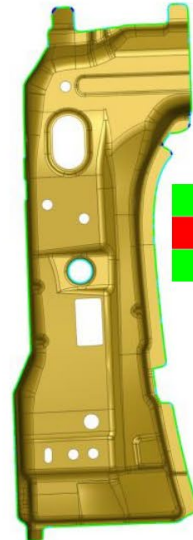


Points in tolerance 0%

Points in tolerance 68%

Points in tolerance 96%

Iteration1

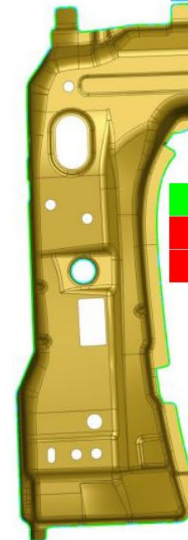


Points in tolerance 100%

Points in tolerance 96%

Points in tolerance 100%

Iteration2

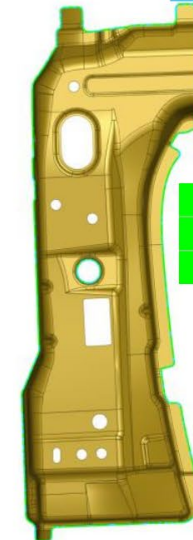


Points in tolerance 100%

Points in tolerance 99%

Points in tolerance 99%

Iteration3



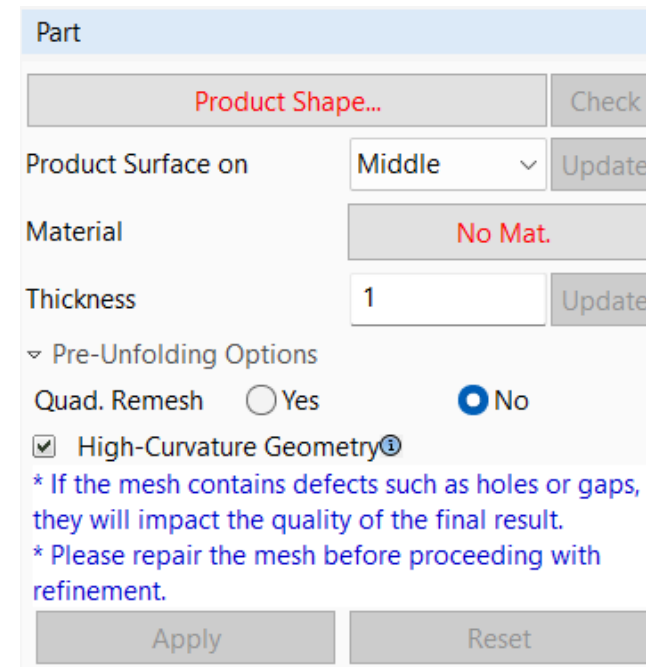
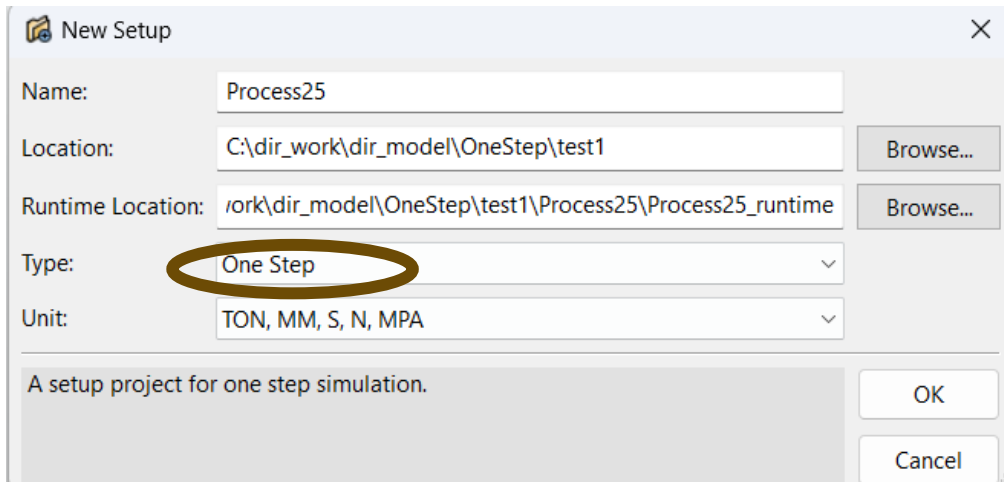
Points in tolerance 100%

Points in tolerance 100%

Points in tolerance 100%

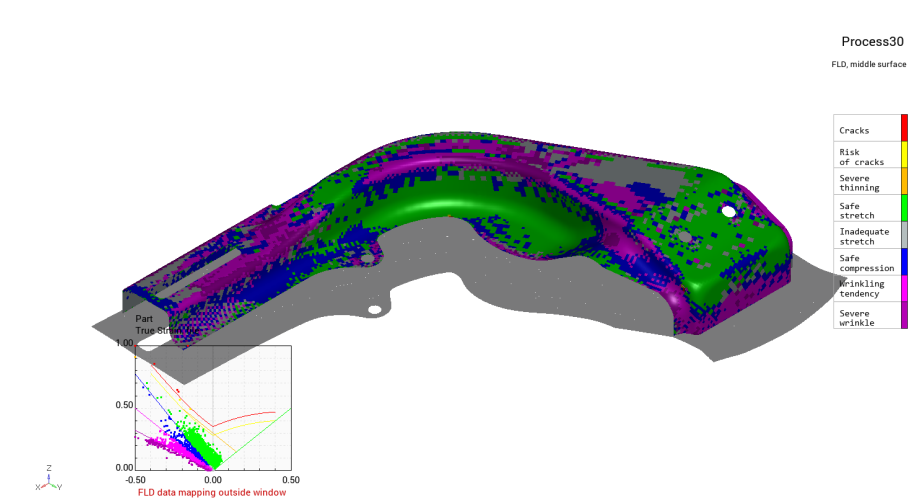
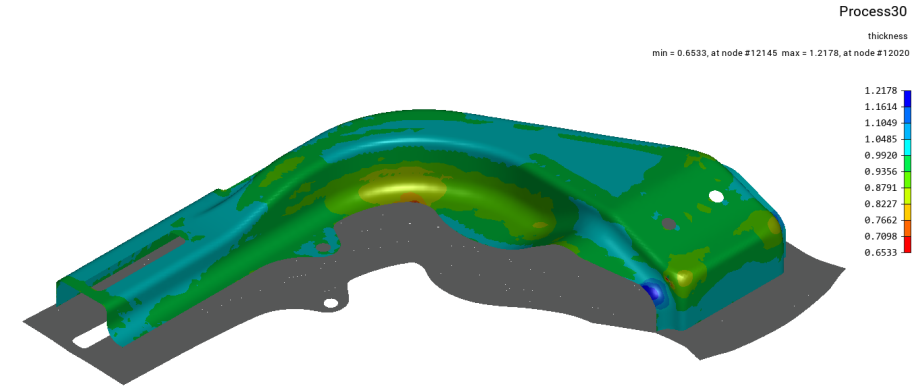
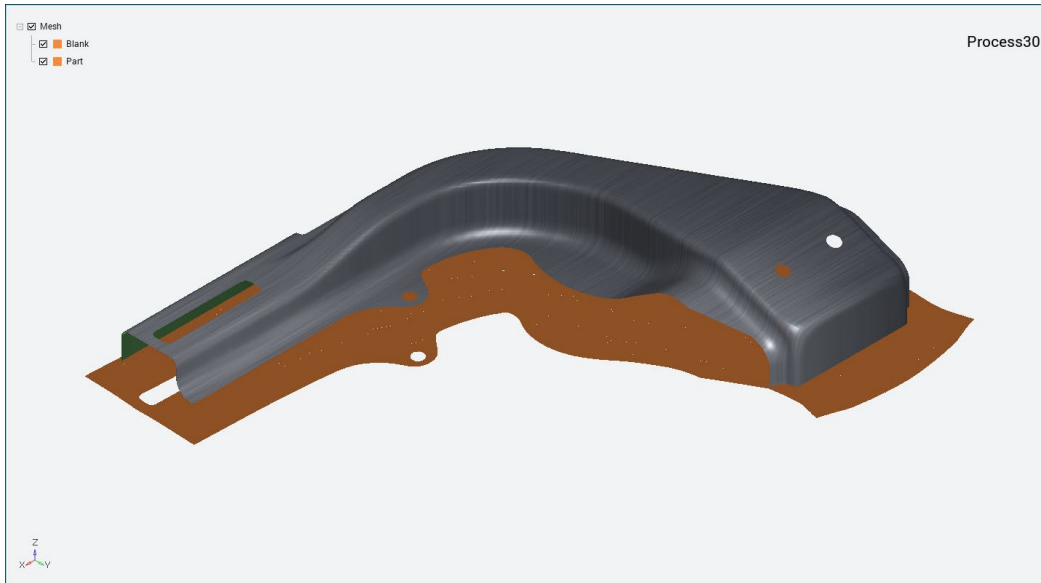
One Step Method

- One step method has been available in the solver
 - Several new important functions have been added
- Friendly use interface will be in the next release



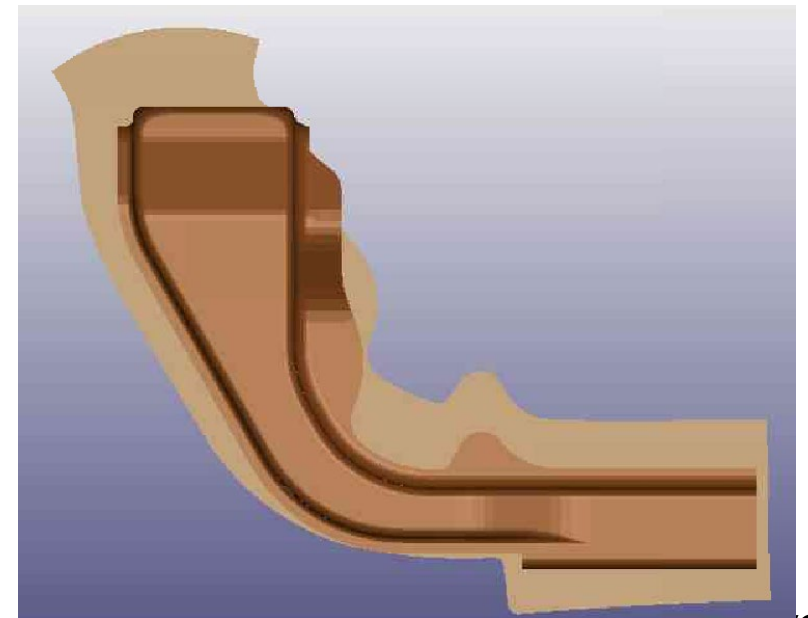
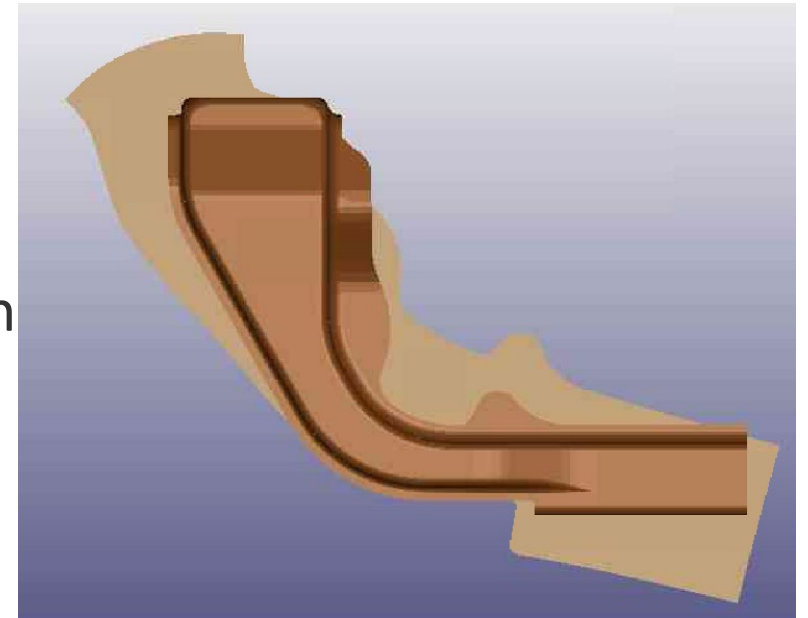
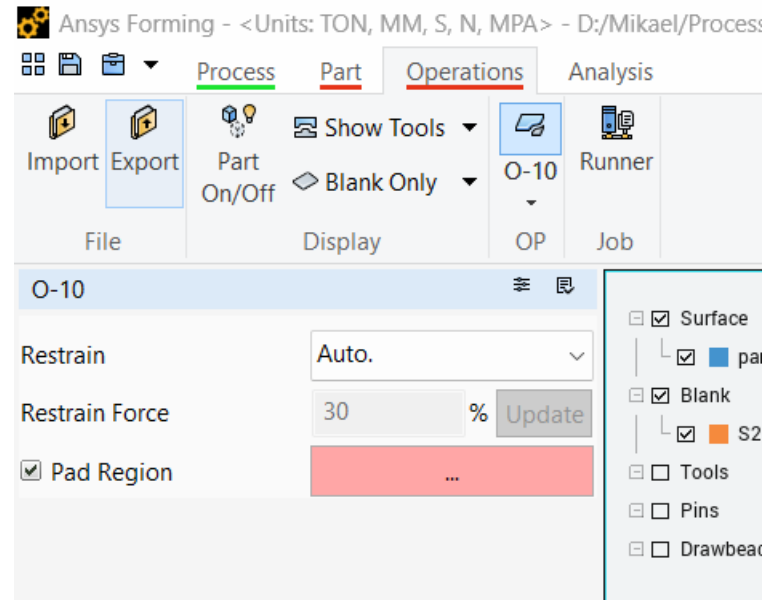
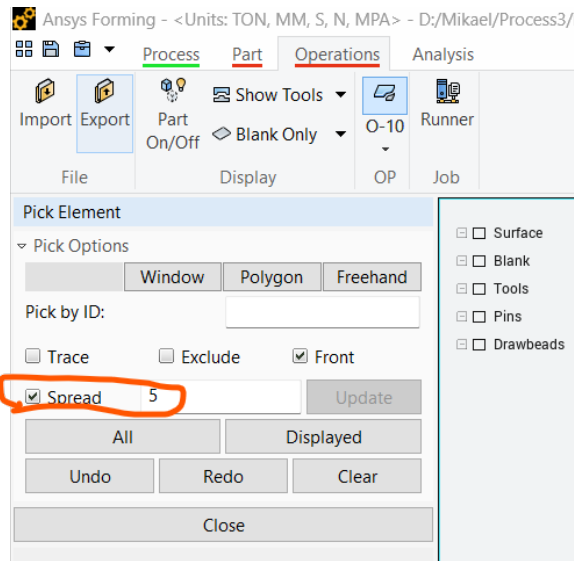
One Step Method - 2

- Auto positioning of the unfolded sheet
- Post processing: FLD, thinning...



One Step Method - 3

- Pad definition
 - Material in the pad region experience small deformation
 - Pad will prevent blank from sliding over the plane

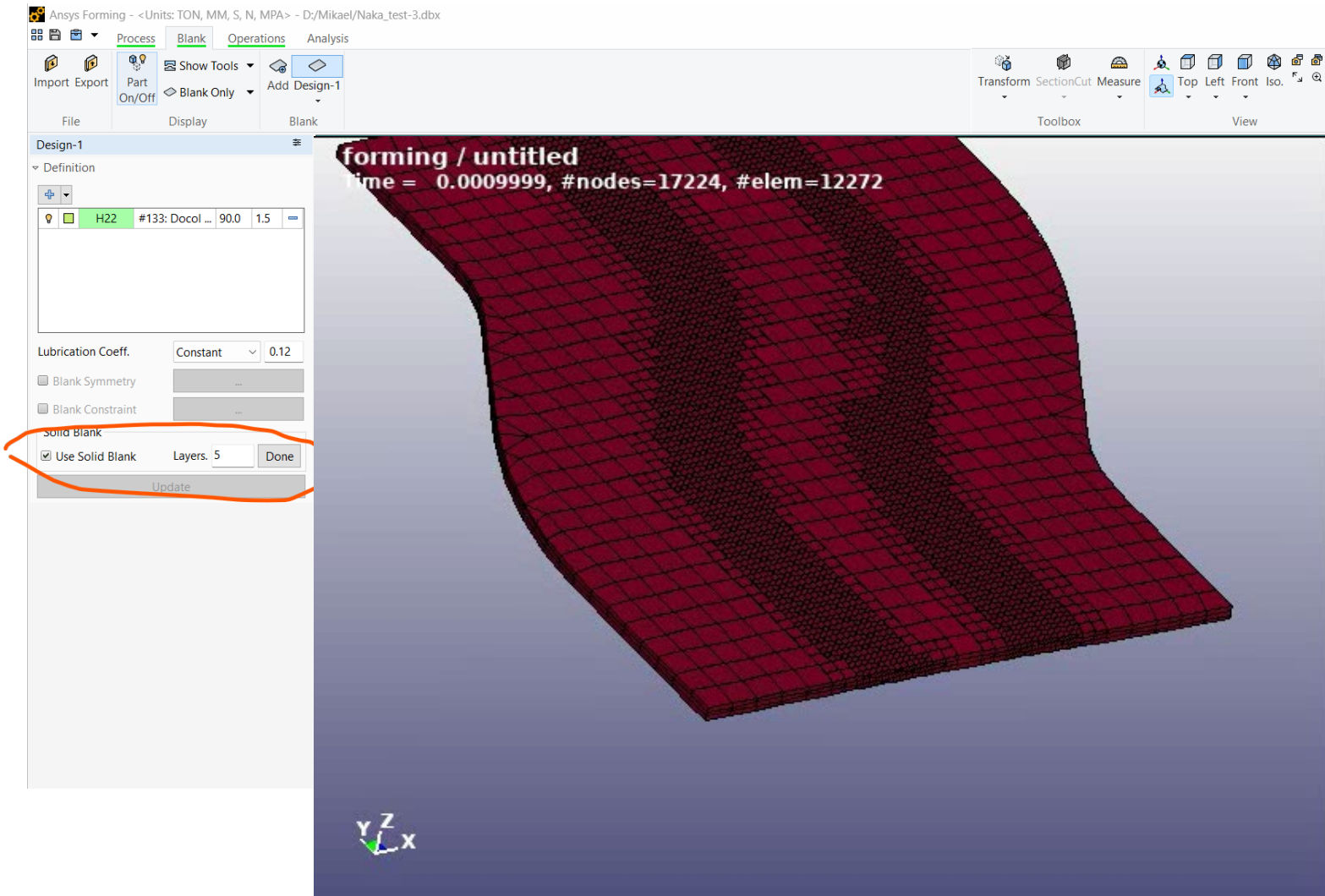




Key Functions

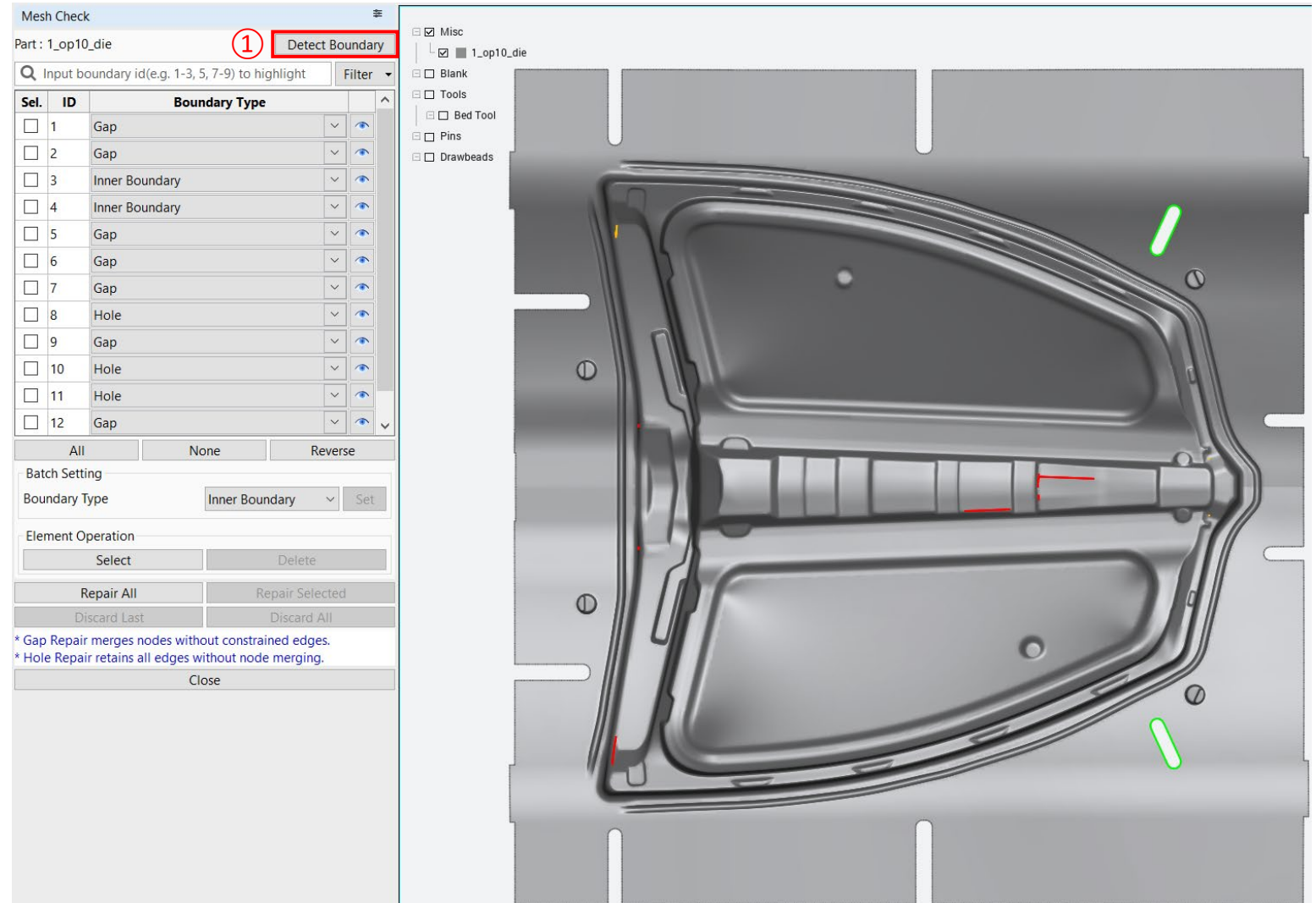
Solid Element

- Use only need to input the number of layers to use solid element in the preprocessing
- Some important functions in using solid elements
 - Enable mesh refinement
 - Enable contact auto normal check to avoid mesh check for the rigid tools
 - Enable contact auto move
 - All the post-processing functions are enabled

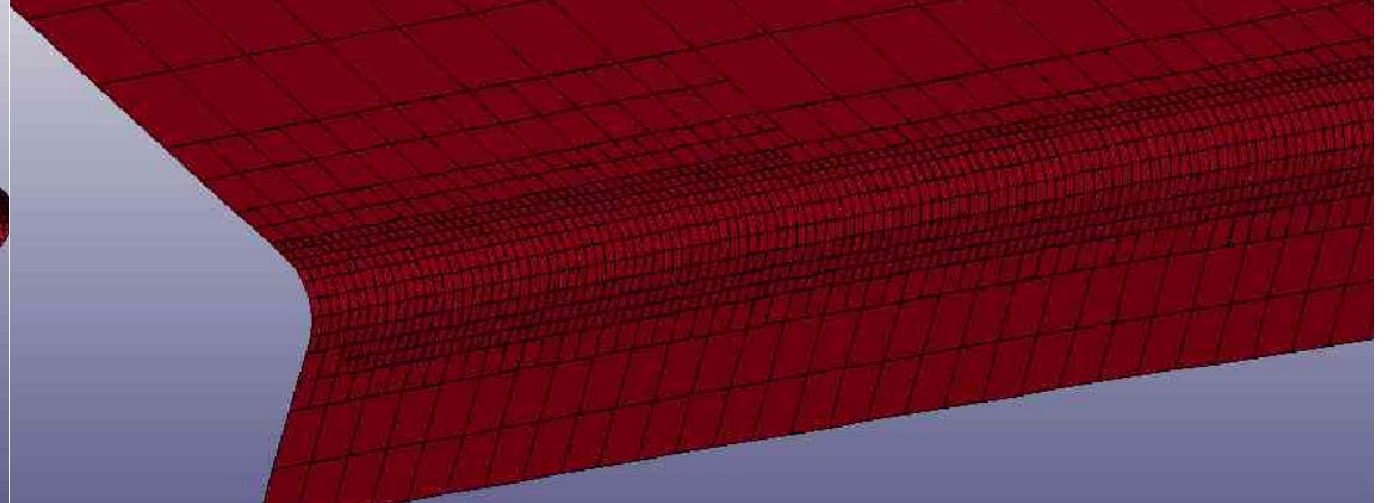
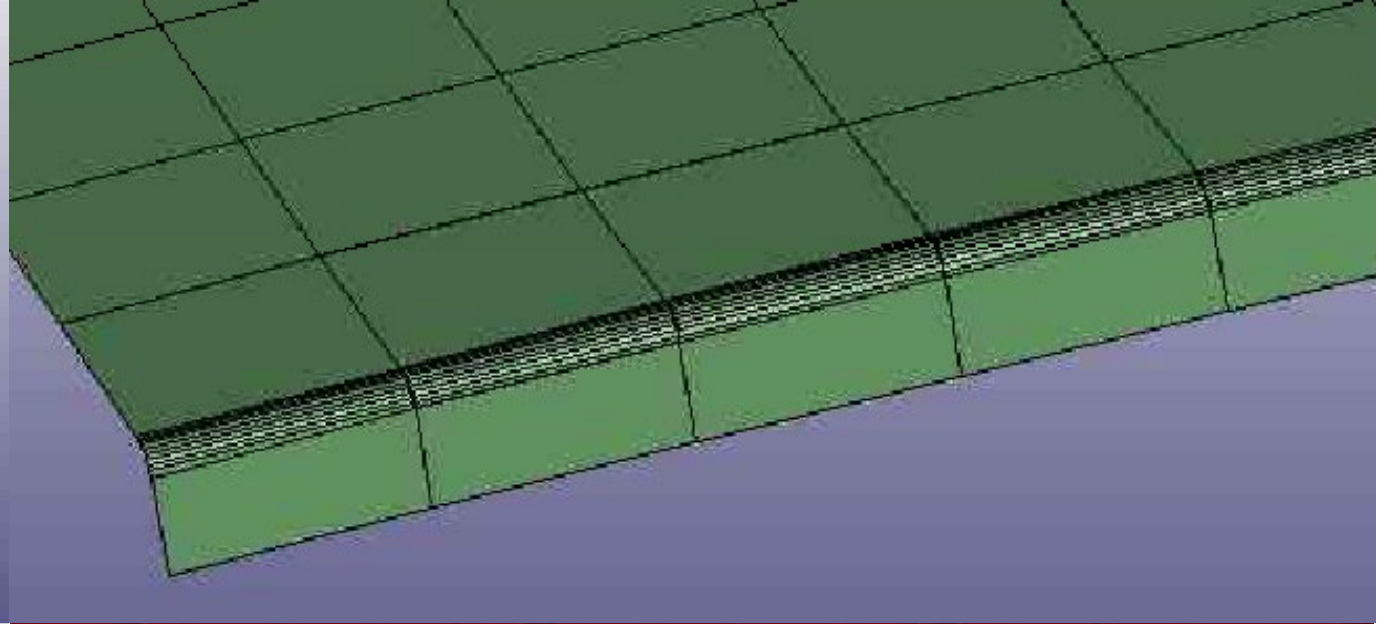
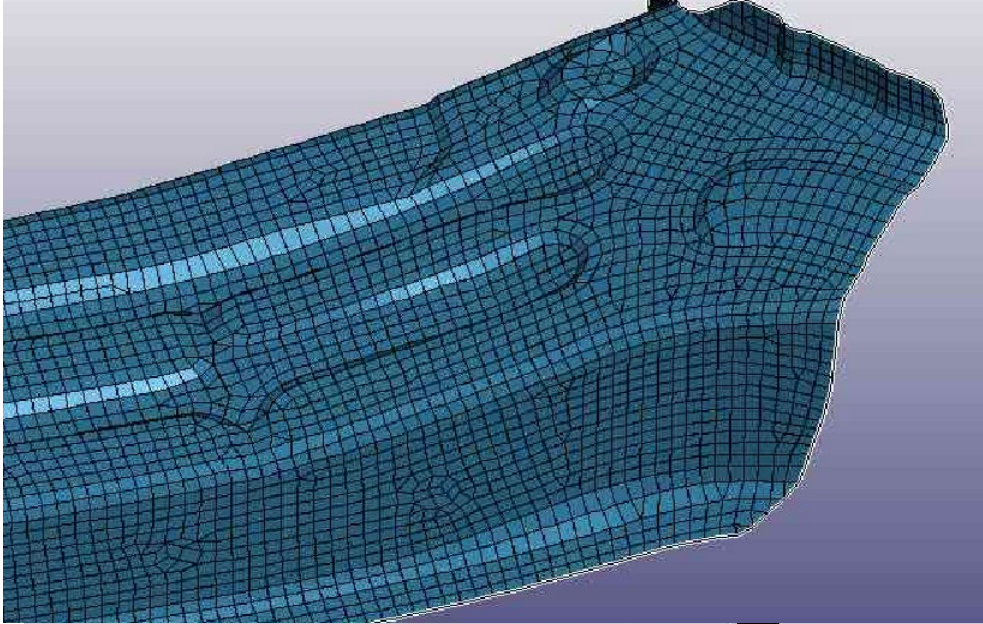


Mesh Check/Repair

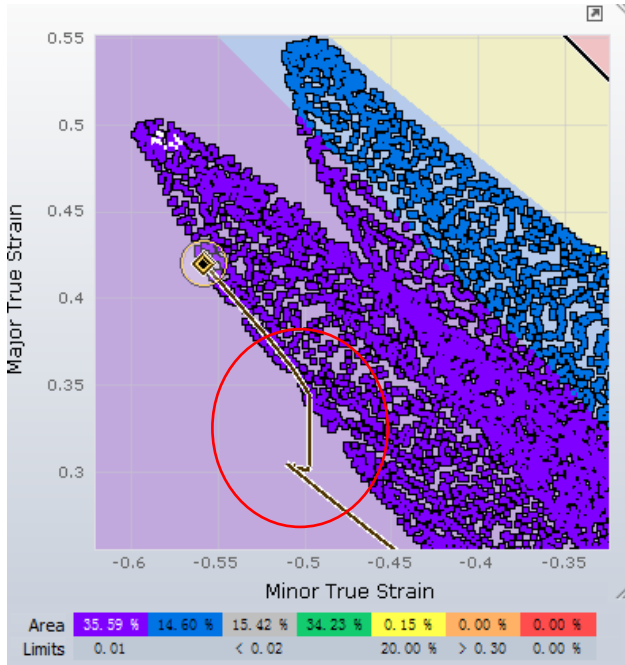
- **Defects** that arise from CAD models or the mesh generation process can significantly impact the accuracy and efficiency of simulations:
 - Holes/Gaps
 - Intersecting/Overlapping/Folding elements
 - Tiny elements with poor quality
- Addressing these issues is critical to ensure the success of simulations and prevent convergence difficulties or simulation failures
- Ansys Forming's **Mesh Check** is designed to identify and rectify these defects
- **Detect Boundary**
 - Removes folding/tiny elements
 - Detects all boundaries
 - Classifies detected boundaries
 - **Inner Boundary**: Retained to represent the true geometry
 - **Hole**: To be repaired by the Hole-Repair method
 - **Gap**: To be repaired by the Gap-Repair method
 - Boundary Type can be changed as needed



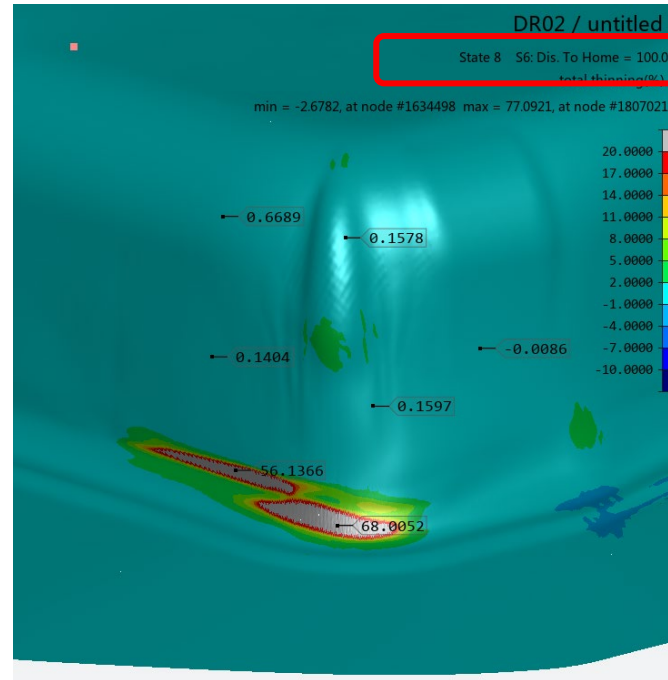
Mesh Regeneration with Mesh Adaptivity



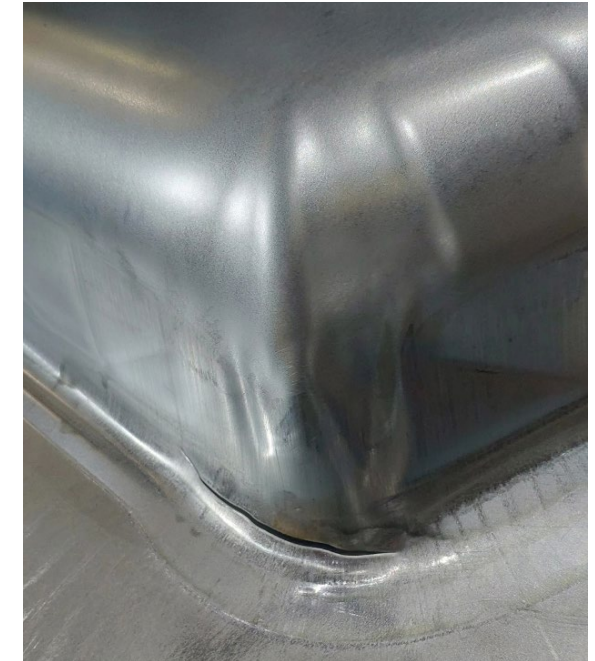
Formability Index



Non-linear strain path



100mm to home (simulation)



100mm to home (real part)

By using Formability Index, the predicted failure is very close to reality, while fails 100mm before the die reach its home position.

With conventional FLD, the failure can not be predicted.

Wrinkling predictions



Real Part

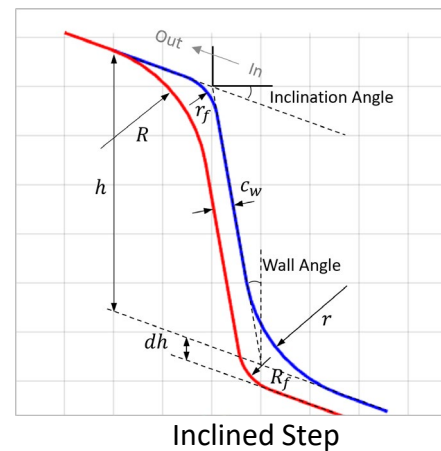
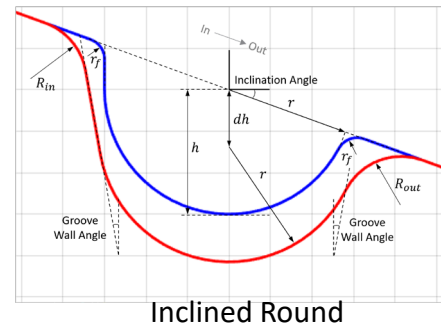
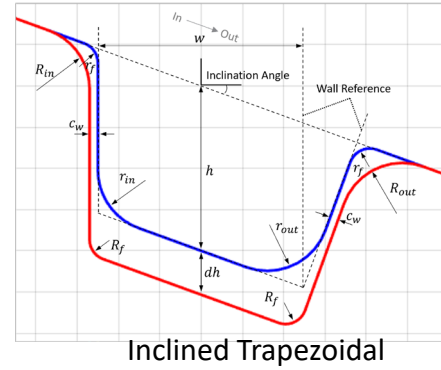
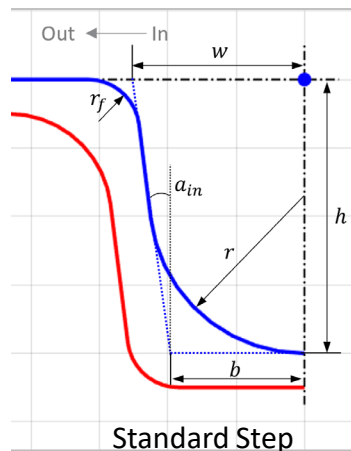
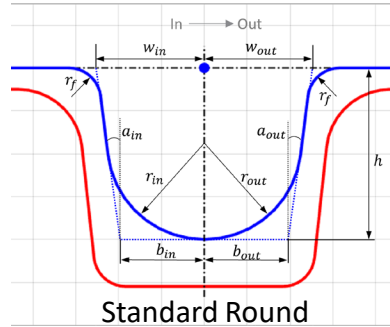
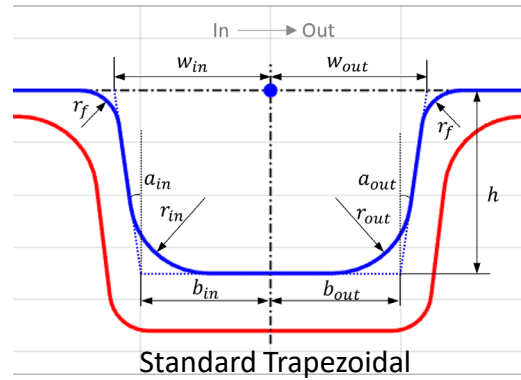
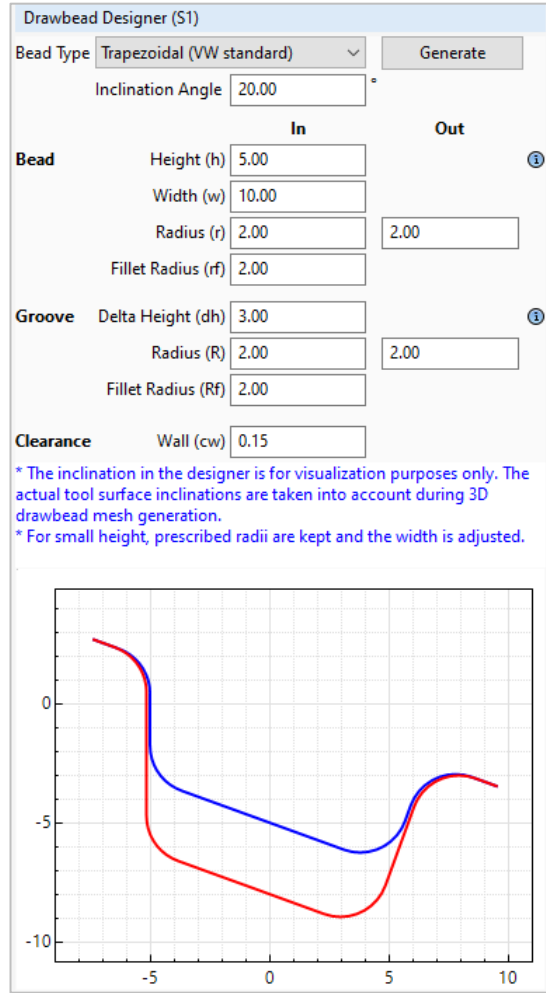


Ansys Forming prediction

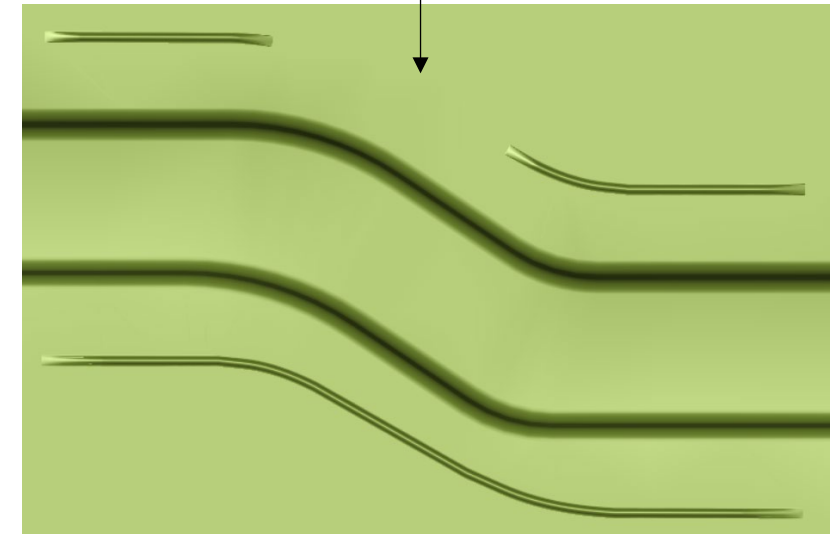
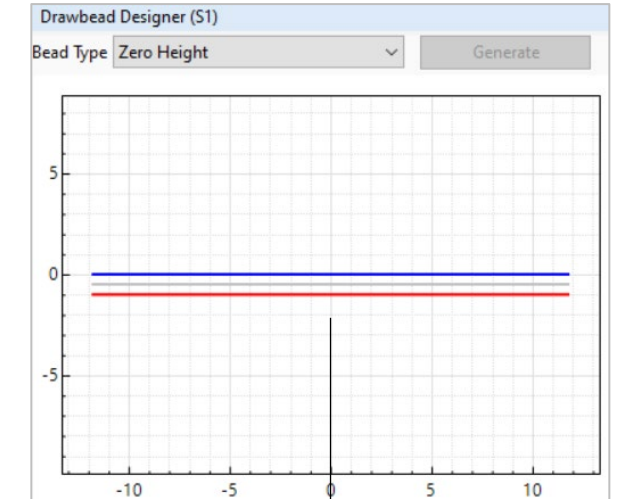
Wrinkling is a very serious problem, especially for ultra-high strength steel
The accurate prediction of wrinkling is not easy.

Drawbead Profile Generator

- Three new **inclination-sensitive** drawbead profile templates, tailored for **curved** surfaces



- Zero-Height** bead for enhanced design flexibility



Drawbead Force Calculation and Prediction

Drawbeads

<<

☒ Drawbead Profile

For all defined drawbeads

Drawbead-1	Drawbead-2

☒ Bead Description ☐ Force Display

☐ Transition Length 40 mm

Total Uplift Force 19328.9 N

3D Drawbead

☐ Use 3D Drawbead

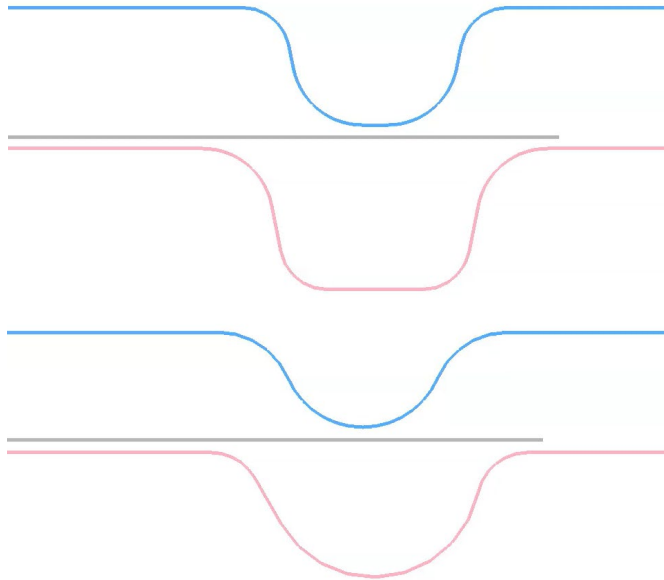
Settings

Attached to: Die Binder

Name	Restrain (N/mm)	Uplift (N/mm)			
S1	300.894	268.837			
S3					
S2					

For one drawbead segment

- Fast and accurate drawbead force calculation based on drawing simulations
- Support all bead types
- Support SMP and MPP solvers
- Support constant friction, variable friction, and user-defined table friction
- Support all materials



Drawbead Designer (S1)

Bead Type: Round

Defined by: Base Width

	In	Out
Wall Angle (a)	18.43	18.43
Height (h)	3.00	
Base Width (w)	3.00	3.00
Top Width (b)	2.00	2.00
Radius (r)	2.77	2.77
Fillet Radius (rf)	2.00	
Height (H)	4.00	
Base Width (W)	3.64	3.64
Top Width (B)	2.31	2.31
Radius (R)	3.00	3.00
Fillet Radius (RF)	0.80	
Wall (cw)	0.15	
Top (ct)	1.00	

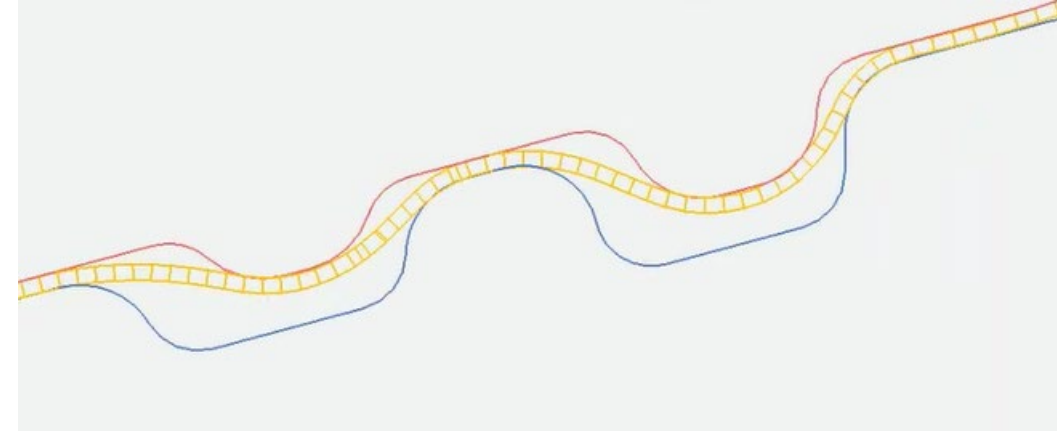
* For small height, prescribed radii are kept and the groove's width is adjusted to ensure the prescribed wall clearance.

Blank Thickness	1.00	Lubrication Coeff.	0.12
Restrain Force	214.06	Uplift Force	185.39

- Real-time machine learning prediction of drawbead forces
- Comparable to drawbead forces calculated by MPP solver
- Support profiles within specified parameter ranges
- Support materials with Hill'48 yield functions
- Support various blank thickness and constant friction coefficients

Non-Linear Contact

- Constant contact stiffness is commonly used in simulation
 - Large stiffness can cause contact instability
 - Small stiffness can increase penetration
- Common observation:
 - Obvious penetration is observed in curved region
- New approach
 - In smooth region, smaller contact stiffness is used
 - In curved region, large contact stiffness is used



A Universal Material Model

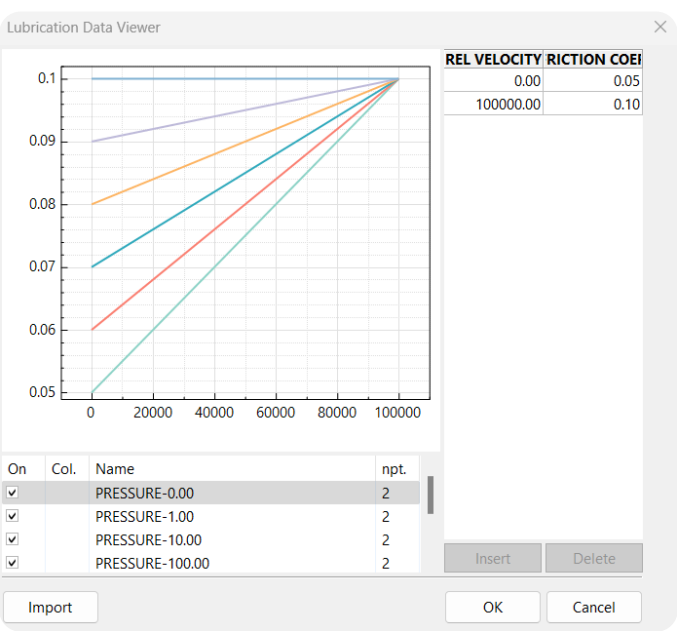
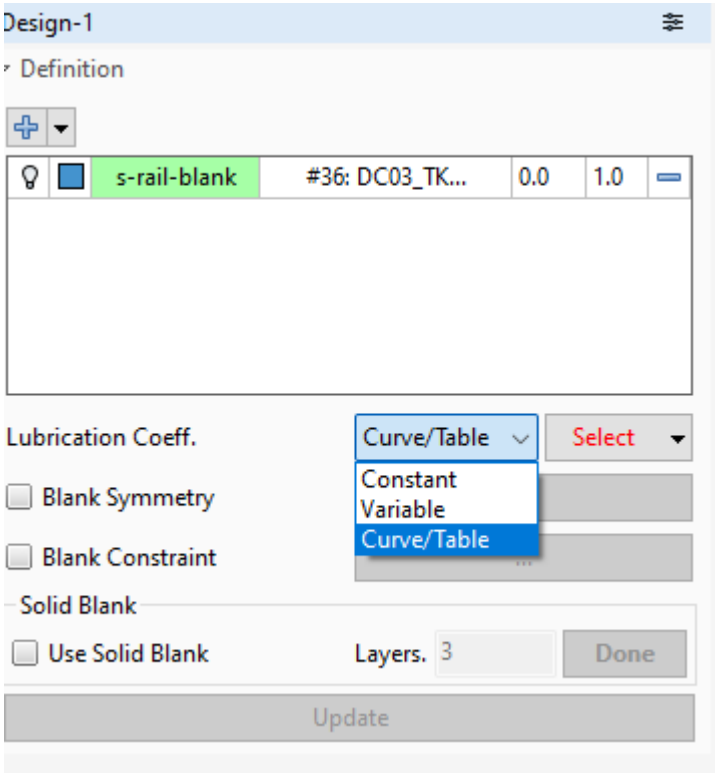
- The purpose of this material model is to improve the performance of the plasticity models
- The application of this material model is intended for sheet metal forming applications
- Only isotropic hardening has been supported

Default Settings	
Options	
Contact Friction	0.12
<input type="checkbox"/> Contact Stiffness	0.1
<input type="checkbox"/> Shell Type (Exp.)	2
<input type="checkbox"/> Shell Type (Imp.)	16
Solid Type (Exp.)	-1
Solid Type (Imp.)	-1
<input type="checkbox"/> NIP	3
<input type="checkbox"/> Shell Shear Stiffness	0.8333
<input type="checkbox"/> Output Distance Interval	5
<input type="checkbox"/> Output Positions	5,4,3,2,1
<input checked="" type="checkbox"/> MAT320 Parameters(IPHI,ITHETA)	501,251
<input type="checkbox"/> Output Contact Info.	0

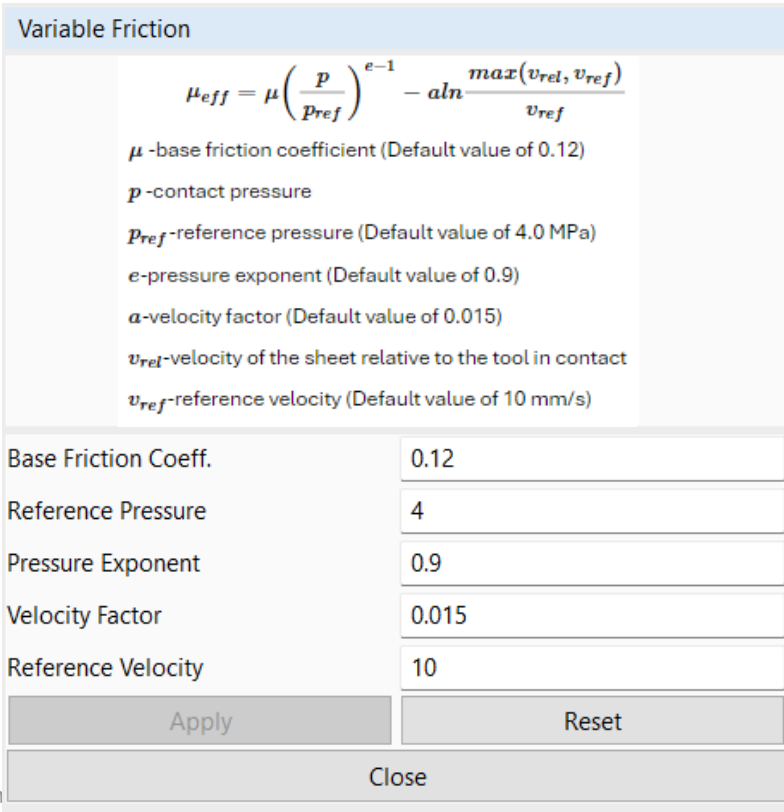
Material used	Run time	Saving (%)
3 parameter Barlat	4 hours 57 minutes 36 seconds	
3 parameter Barlat NLP	5 hours 7 minutes 14 seconds	
Barlat 2000	4 hours 35 minutes 2 seconds	
MAT320 + 3 parameter Barlat	3 hours 56 minutes 9 seconds	1 hr 1min 27s (20%)
MAT320 + 3 parameter Barlat NLP	3 hours 58 minutes 16 seconds	1 hr 8min 58s (22%)
MAT320 + Barlat 2000	3 hours 56 minutes 3 seconds	0 hr 38min 59s (14%)

Variable Friction Coefficient

- Friction coefficient can be defined as a function of contact pressure and relative velocity
 - It support both a friction function or user input table



Visualization of the tabular data



Reconfigurable setting

- Each company/engineer can define the setting
 - Color
 - Range
 - Easy to prepare report

Contour Component Configuration

Reset Category: Contour

Component	Title	Group	Overriden
PRIN_STRAIN1_PLANE	major strain	Forming	<input type="checkbox"/>
PRIN_STRAIN2_PLANE	minor strain	Forming	<input type="checkbox"/>
THINNING	total thinning(%)	Forming	<input type="checkbox"/>
THINNING_CURRENT	current op thinning(%)	Forming	<input type="checkbox"/>
THINNING_ZSTRAIN	thinning(%) base on thickness-strain	Forming	<input type="checkbox"/>
THICKNESS	thickness	Forming	<input type="checkbox"/>
BEND_STRAIN	bending strain	Forming	<input type="checkbox"/>
MEAN_STRESS	mean stress	Forming	<input type="checkbox"/>
FORMING_INDEX	formability index	Forming	<input type="checkbox"/>
STRAIN_RATIO	strain ratio	Forming	<input type="checkbox"/>
PLASTIC_STRAIN	effective plastic strain	Forming	<input type="checkbox"/>
SIGMA_XX	x-stress	Stress	<input type="checkbox"/>
SIGMA_YY	y-stress	Stress	<input type="checkbox"/>
SIGMA_ZZ	z-stress	Stress	<input type="checkbox"/>
SIGMA_XY	xy-stress	Stress	<input type="checkbox"/>
SIGMA_YZ	yz-stress	Stress	<input type="checkbox"/>
SIGMA_ZX	zx-stress	Stress	<input type="checkbox"/>
PRIN_STRESS1	1st-principal stress	Stress	<input type="checkbox"/>
PRIN_STRESS2	2nd-principal stress	Stress	<input type="checkbox"/>
PRIN_STRESS3	3rd-principal stress	Stress	<input type="checkbox"/>
VONMISES	von mises stress	Stress	<input type="checkbox"/>
SHEAR_STRESS	tresca (max shear stress)	Stress	<input type="checkbox"/>
EPSON_XX	x-strain	Strain	<input type="checkbox"/>
EPSON_YY	y-strain	Strain	<input type="checkbox"/>
EPSON_ZZ	z-strain	Strain	<input type="checkbox"/>
EPSON_XY	xy-strain	Strain	<input type="checkbox"/>
EPSON_YZ	yz-strain	Strain	<input type="checkbox"/>
EPSON_ZX	zx-strain	Strain	<input type="checkbox"/>
PRIN_STRAIN1	1st-principal strain	Strain	<input type="checkbox"/>
PRIN_STRAIN2	2nd-principal strain	Strain	<input type="checkbox"/>
PRIN_STRAIN3	3rd-principal strain	Strain	<input type="checkbox"/>
BEND_MOMENT_MXX	mx bending	Bend Moment	<input type="checkbox"/>

Default

Min. Max. Upper Color Lower Color Reverse Color Number of Color 10 Apply

User-defined

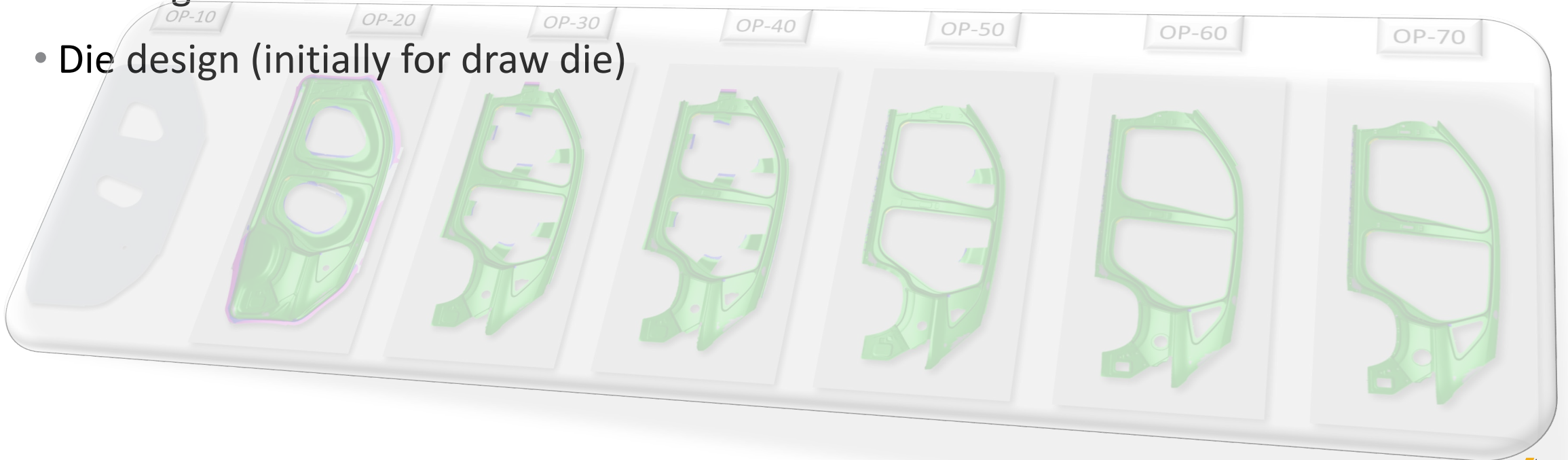
☐ Inherit All

Min. Max. Upper Color Lower Color Reverse Color Number of Color Apply

Import... Export... Save Close

Exciting Future

- Springback compensation of line dies
- Morphing of CAD surface after springback compensation
- Auto reporting
- Nesting and cost estimation
- Die design (initially for draw die)



The Ansys logo, featuring a stylized yellow and black 'A' followed by the word 'nsys' in black.

